Comparative Oral Bioavailability of PBDEs from Dust and Oil in Male Rats

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Introduction.

Recently, indoor dust has been implicated as a major source of polybrominated diphenyl ether (PBDE) exposure in humans and may account for an estimated 60% of the daily intake on average (Jones-Otazo et al. 2005). For children an even larger percentage of daily exposure is estimated to result from dust and soil ingestion (90%). This finding has important implications especially for young children who may be more susceptible to some of the putative developmental effects of PBDEs (Birnbaum and Staskal 2004). Although PBDEs are routinely found in household dust (Stapleton et al. 2005a; Wilford et al. 2004; Sjödin et al. 2004a), uncertainties remain as to the amount of dust ingested by adults or children and the extent to which the PBDEs in dust are bioavailable. To begin to answer the question of bioavailability, we have conducted a study to determine and compare the absorption, distribution, and excretion of PBDEs in rats fed either a dust reference material or corn oil contaminated with PBDE congeners and here present the results of the transfer of PBDEs from the dust and oil doses into adipose tissue.

Materials and Methods.

Sixteen male Sprague-Dawley rats (216.1 ± 7.13 g) were fed either dust (NIST Standard Reference Material 2585) co-mixed in ground feed or ground feed topped with corn oil containing a mixture of PBDEs. Two dose levels (1x and 6x) were given in each matrix to groups of 4 rats each. The rats were fed known amounts of feed (12 g), dust (0.28 or 0.05 g), and an oil dose (0.2 mL) once a day for 21 days. Four control rats (213.8 ± 11.72 g) were fed an identical amount of ground feed (12 g) each day. Twenty four hours after the last feeding, the rats were sacrificed, and blood and numerous tissues were collected. Urine and feces were collected throughout the experiment. PBDEs from epididymal adipose tissue were purified on an automated Power Prep unit (Fluid Management System, Waltham, MA) and quantitated by HR-GC/HR-MS analysis according to a previously reported method (Huwe and Larsen 2005). If a congener was not detected in the adipose, the limit of detection (S/N = 3) is given.

Results and Discussion.

For this study, the dosing levels were chosen to mimic low level environmental exposures while still providing concentrations of the PBDEs in tissues sufficiently above the analytical detection limits, especially for the more highly brominated congeners. The dust was a Standard Reference Matrix obtained from the National Institute of Standards and Technology (NIST) and had previously been shown to contain PBDEs (Stapleton et al. 2005b). The oil dose was prepared by mixing commercial penta-, octa-, and deca-BDE formulations into corn oil to simulate the levels in the dust. The high doses were nominally 100 ng total PBDEs/g feed (Table 1) and provided daily doses of 1.1 µg (oil) and 1.7 µg (dust) of total PBDEs. The daily amount of dust fed (0.05 g or 0.28 g) was near the minimum and maximum

amounts of estimated soil/dust intake by children (0.01 – 0.2 g/d) (Jones-Otazo et al. 2005) and was readily consumed by the rats.

The concentrations of the major PBDEs in the dose and the adipose tissues for the high dose groups of rats are shown in Table 1. These congeners represent over 98% of the PBDEs in the dose and the adipose tissues. Apparent bioconcentration factors (BCFs) were calculated from this data for each PBDE as the ratio of the concentration in the adipose tissue to the concentration in the diet. BCFs of individual congeners from both the high and low dose groups are plotted in Figure 1. BCFs were similar for all dosage groups; however, several congeners in the high dust dose tended to concentrate to a somewhat greater extent than in the corresponding oil dose (BDEs-47, 100, 85, and 153). At this time we have no plausible explanation for this difference. In general, the apparent adipose BCFs ranged from 10 – 20 for tri- to hexa-BDEs, 1 – 5 for hepta- to nona-BDEs, and <1 for deca-BDE. This trend is similar to uptakes of PBDEs reported in fish tissues (Burreau et al. 1997) and in rat carcasses (Huwe et al. 2007, Huwe 2005). An interesting observation was the difference in bioconcentrating potential between BDEs-154 and 153. In all dose groups, BDE-153 concentrated into the adipose by a 3 – 4-fold higher rate than BDE-154. One reason for this may be the low metabolism of BDE-153 compared to BDE-154. Sanders et al. (2006) have shown BDE-153 to be resistant to metabolism in rats; however, at least 24% of a BDE-154 dose to rats was identified as metabolites (Hakk et al. 2005).

The present study shows that PBDEs in dust are at least as bioavailable as those dissolved in an oil vehicle and that BDE-154 and hepta- to deca-BDEs concentrate into adipose to a lesser degree than other major congeners. These results indicate that dust can be a potential source of PBDEs in rats and perhaps other mammals. Further investigations into the bioconcentration and distribution of PBDEs from dust into other tissue compartments are underway.

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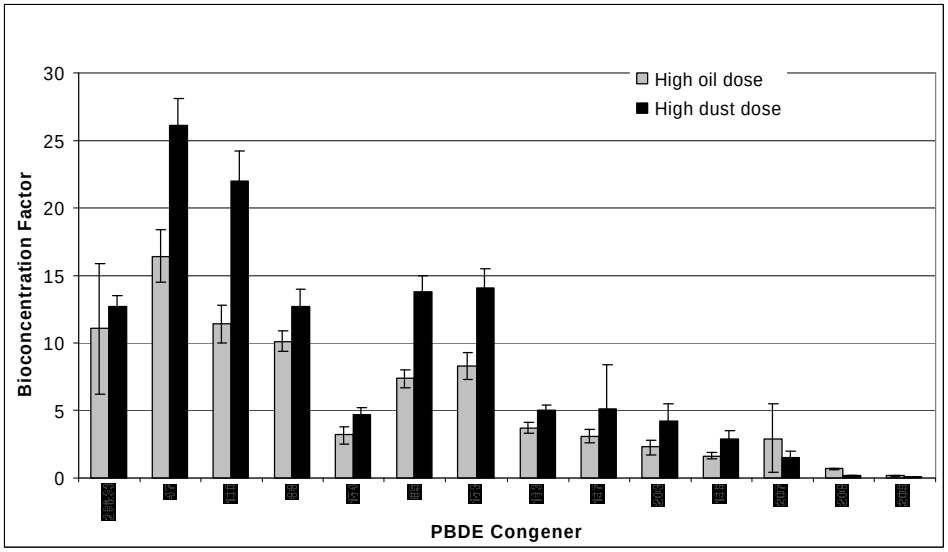
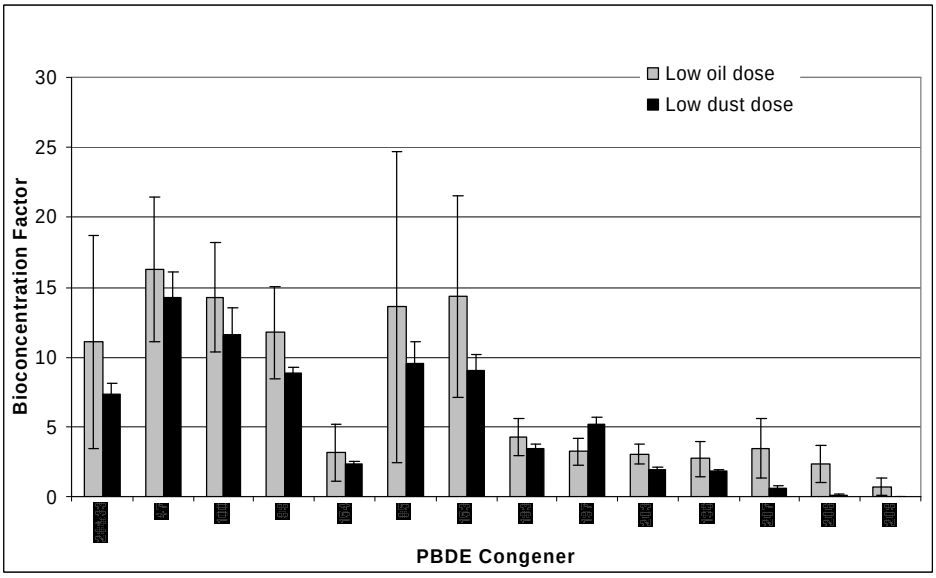
Table 1. Concentration of major PBDEs in the dose and in the adipose tissues of rats receiving an oral dose in a dust or corn oil matrix. For non-detected congeners (Nd), the limit of detection is given in parentheses.

BDE #	High dust dose group		High oil dose group	
	Dose (ng/g feed)	Adipose tissue (ng/g) N = 4	Dose (ng/g feed)	Adipose tissue (ng/g) N = 4
28/33	1.33	16.8 ± 1.1	0.05	0.5 ± 0.2
47	11.0	287.1 ± 21.5	7.81	128.4 ± 15.4
100	2.99	65.7 ± 6.6	2.97	33.9 ± 4.2
99	19.27	245.7 ± 25.1	14.60	147.8 ± 10.9
154	1.90	8.8 ± 1.0	1.40	4.5 ± 0.9
85	0.71	9.8 ± 0.8	0.68	5.0 ± 0.5
153	2.80	39.5 ± 3.9	1.89	15.6 ± 1.9
183	1.19	6.0 ± 0.4	1.04	3.8 ± 0.4
197	0.31	1.6 ± 1.0	0.47	1.4 ± 0.2
203	0.49	2.1 ± 0.6	0.12	Nd (0.3)
196	0.43	1.2 ± 0.3	0.15	Nd (0.3)
207	2.41	3.6 ± 1.3	0.75	2.2 ± 1.9
206	5.04	Nd (0.9)	1.22	Nd (0.8)
209	86.56	8.3 ± 3.2	62.02	9.8 ± 2.5
Sum	136.4		95.1	



A.



B.

Figure 1. Apparent bioconcentration factors for individual PBDEs from A) a high dose (6x) in dust or corn oil and B) a low dose (1x) in dust or corn oil. Bioconcentration factors are the ratio of the concentration in adipose tissue (pg/g lipid) to the concentration in the feed (pg/g feed). Error bars represent the standard deviations of the four individual rats.